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OSTEOLOGICAL EVIDENCE FOR THE PRIOR OCCURRENCE OF A GIANT GECKO IN OTAGO, NEW ZEALAND

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ABSTRACT: Reevaluation of a mandibular ramus and "rib" discovered at Earnscleugh, Otago, New Zealand suggests that the bones are assignable to a gekkonid lizard of gigantic size. The "rib" is consistent in form with a cloacal bone, a feature lacking in other New Zealand lepidosaurian reptiles. A comparison with many gekkonid cloacal bones, including that of *Hoplodactylus delcourti*, the largest gecko known to have ever lived, indicates that the Earnscleugh lizard was between 275 and 325 mm in snout-vent length. The applicability of the Maori names *kawekaweau, ngarara,* and *kumi* to the Otago remains is discussed.

INTRODUCTION

Hoplodactylus delcourti is the largest gekkonid lizard known to have ever lived (Russell and Bauer 1986). This species has been described from a single skin and partial skeleton preserved in the Marseille Natural History Museum since the 19th century (Fig. 1), the biological significance of which has only recently been recognized (Bauer and Russell 1986). The specimen measures 370 mm in snout-vent length [SVL] (total length is 622 mm), and therefore exceeds the next largest species, the New Caledonian giant forest gecko, *Rhacodactylus leachianus,* by 54%. The magnitude of this size in gekkonid terms may be appreciated by noting that fewer than 30 of the 800+ gecko species attain a body length of even one-third (and hence a body weight approximately $\frac{1}{27}$) that of *H. delcourti.*

Unfortunately, no locality data accompany the Marseille holotype of *Hoplodactylus delcourti.* Nonetheless, Bauer and Russell (1986, 1987) have argued for a New Zealand origin on the basis of both morphological and ethnographic evidence. Although the skeleton is incomplete, the skull and limb bones are present, and have been examined by means of radiography. Osteology, along with certain features of toe structure and scalation, demonstrates the affinity of the species to the paraphyletic grouping of endemic New Zealand "brown geckos" currently placed in the genus *Hoplodactylus* (Bauer 1986).

Additional evidence drawn from early European reports (Mair 1873, Buller 1895, Walsh 1905), as well as Maori folklore (Best 1909, 1923), has led us to postulate that *H. delcourti* is identifiable with the Maori name *kawe-*

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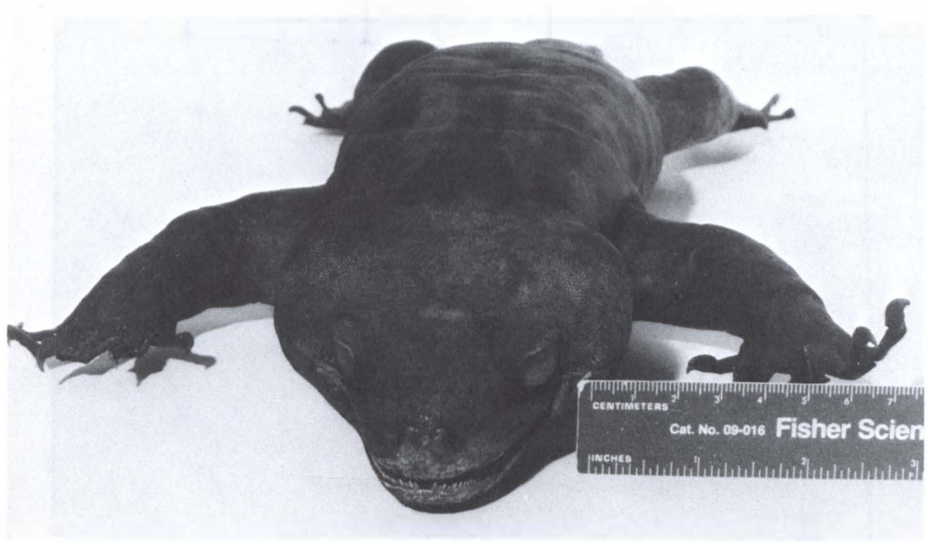

FIG. 1.—Head-on view of the holotype of *Hoplodactylus delcourti* (MNHM 1985-35), the largest known gecko.

kaweau, used in reference to a large, lizard-like creature (mistakenly identified by Williams [1975] as the tuatara, *Sphenodon punctatus*), known until about 1875 from various localities on North Island, New Zealand (Fig. 2). Details supporting our identification are provided elsewhere (Bauer and Russell 1987). Confirmation of both the New Zealand origin of *Hoplodactylus delcourti* and its association with the *kawekaweau,* and perhaps other Maori reptile names, must await the location of additional specimens (living or subfossil). We here report on osteological evidence first presented by Hutton (1875, 1899) that suggests that *Hoplodactylus delcourti,* or an unknown gecko of similar size, once occurred in Otago, on South Island, New Zealand.

The evidence derives from two bones discovered in the Earnscleugh Cave in Central Otago, near the present town of Clyde (Fig. 2). The age of the cave deposits is quite recent (Hutton 1875), as indicated by the co-occurrence of rats (introduced by man ca. 1000 A.D.) with moas, tuataras, and other small native animals. Hutton (1875) believed that the remains dated only from the beginning of the 19th century. The lizard bones in question are a lower jaw ramus with pleurodont dentition (teeth attached to the inner side of the jaw) (Fig. 3), "about the size of that of a tuatara" (Hutton 1875, 1899: 485), and a small bone (Fig. 4A) described by Hutton (1899) as "what appears to be a small vertebral rib, belonging to the left side, and which may possibly

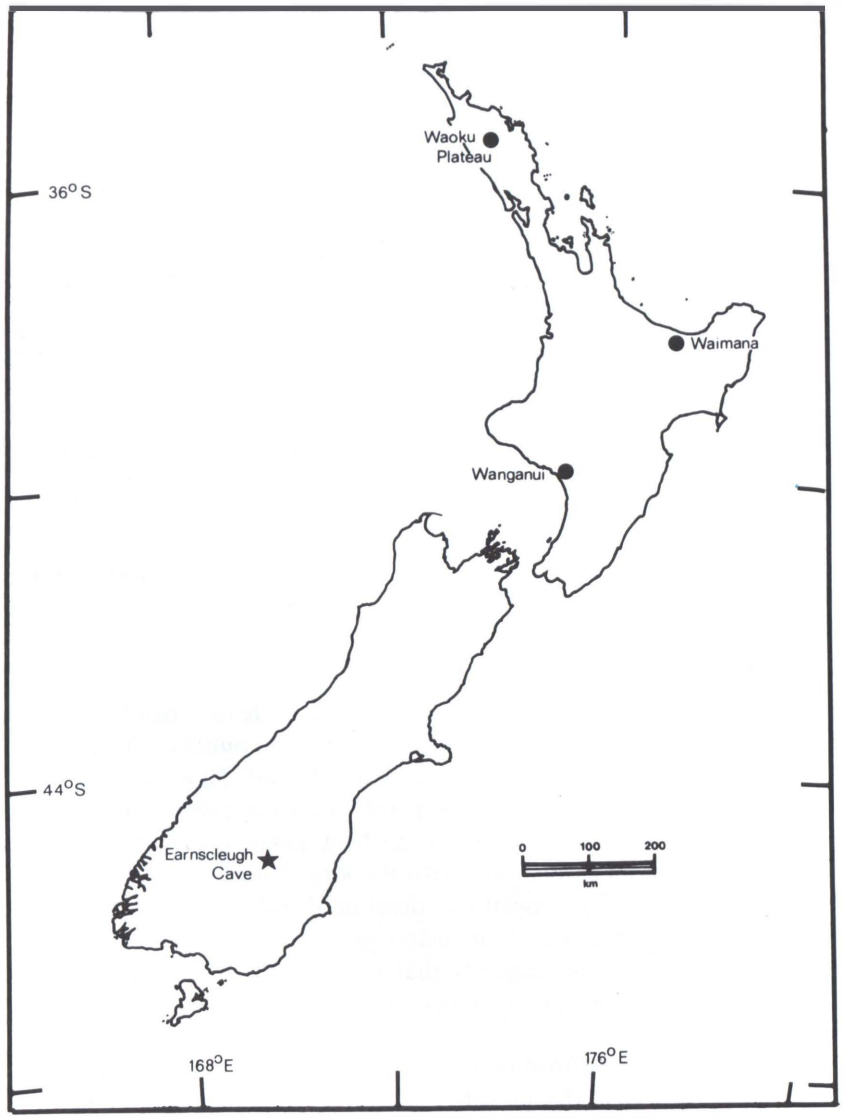

FIG. 2.—Map of New Zealand indicating localities associated with the *kawekaweau* (*H. delcourti*)—circles; and the cave deposits discussed by Hutton (1875, 1899)—star.

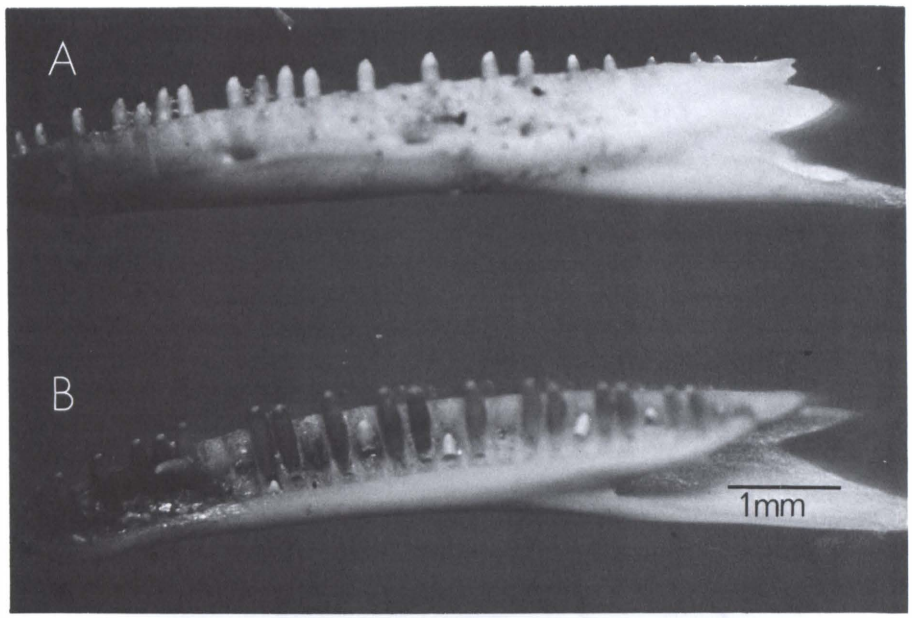

FIG. 3.—A. Lateral (labial) and B. medial (lingual) views of the mandible of *Hoplodactylus maculatus* showing pleurodont dentition.

have belonged to the same animals [as the jaw]. It may be the last cervical of a reptile."

METHOD

The Hutton (1875, 1899) literature descriptions and figure were compared with radiographs of *Hoplodactylus delcourti* and with radiographs, dry skeletal preparations, and cleared and stained specimens (see Wassersug 1976 and Hanken and Wassersug 1981 for technique protocol) of representative species of the following gekkonid genera: Subfamily Eublepharinae—*Aeleuroscalabotes, Coleonyx, Eublepharis, Hemitheconyx, Holodactylus*; Subfamily Diplodactylinae—*Bavayia, Carphodactylus, Crenadactylus, Diplodactylus, Eurydactylodes, Hoplodactylus, Naultinus, Nephrurus, Oedura, Phyllurus, Pseudothecadactylus, Rhacodactylus, Rhynchoedura*; Subfamily Gekkoninae—*Afroedura, Agamura, Ailuronyx, Alsophylax, Bogertia, Briba, Bunopus, Calodactylodes, Chondrodactylus, Cnemaspis, Colopus, Cosymbotus, Crossobamon, Cyrtodactylus, Geckonia, Gehyra, Gekko, Hemidactylus, Hemiphyllodactylus, Heteronotia, Homonota, Homopholis, Lepidodactylus, Luperosaurus, Nactus, Pachydactylus, Palmatogecko, Perochirus, Phelsuma, Phyllodactylus, Phyllopezus, Ptenopus, Ptychozoon, Ptyodactylus, Rhoptropus, Stenodactylus, Tarentola, Teratoscincus, Teratolepis, Thecadactylus,*

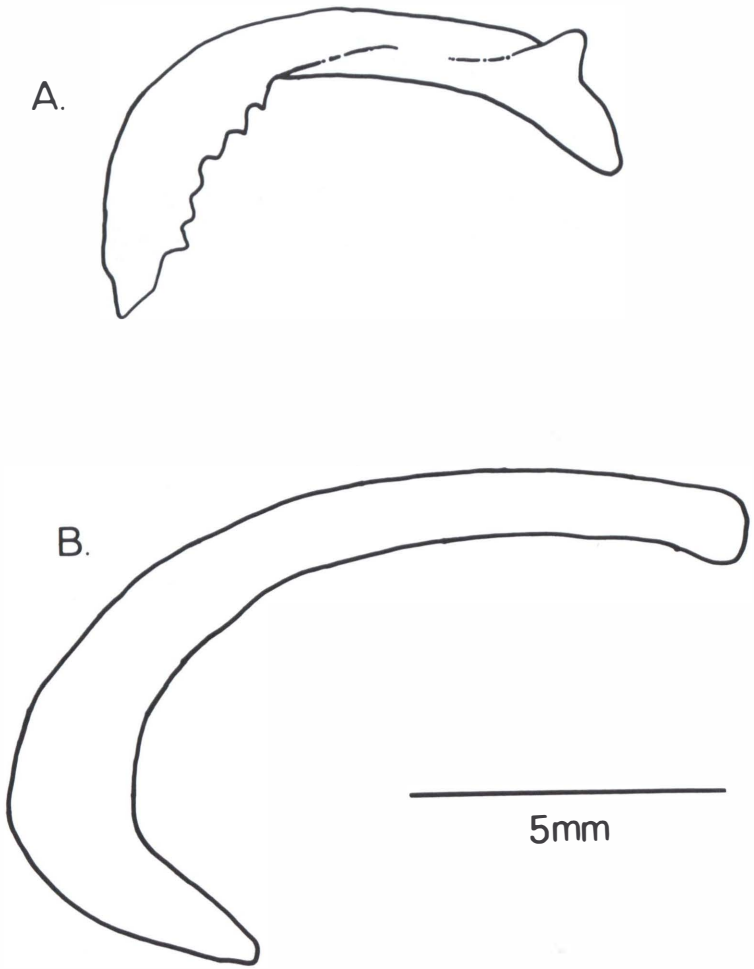

FIG. 4.—A. Hutton's (1899) illustration of the Earnscleugh "rib" (redrawn in horizontal orientation). B. The right cloacal bone of *Hoplodactylus delcourti* (MNHM 1985-35) drawn to same scale as Fig. 3A. Details of the morphology of this element cannot be seen in the radiographs from which it was drawn, hence only an outline is presented.

Tropicolotes, Uroplatus. Within *Hoplodactylus,* seven of the eight congeners of *H. delcourti* (*H. chrysosireticus, H. duvaucelii, H. granulatus, H. maculatus, H. pacificus, H. rakiurae* and *H. stephensi*) were examined. Only the recently described *H. kahutarae* (Whitaker 1985) was unavailable for comparison. A small number of skink and *Sphenodon* skeletons were also examined.

FIG. 5.—A tuatara, *Sphenodon punctatus,* biting a stick and revealing its acrodont dentition. Photo taken on Lady Alice Island, New Zealand.

EVALUATION OF THE EARNSCLEUGH LIZARD REMAINS

Lower jaw.—Unfortunately, Hutton does not provide an illustration of the lower jaw ramus from Earnscleugh. He states, however, that the dentition was pleurodont (Fig. 3), and that the size was about that of a tuatara (*Sphenodon punctatus*) jaw. The dentition alone is sufficient to rule out *Sphenodon* as the animal involved, as it is typified by acrodont dentition (teeth attached to dorsal surface of dentary) (Fig 5), rather than pleurodont dentition.

The pleurodont condition is found in both of the families of lizards known from New Zealand, the Gekkonidae and Scincidae. The size of the jaw ramus from Earnscleugh would appear to have been approximately 75 mm total length. This value was determined by averaging the mandibular lengths of a sample of tuataras (n = 5) within the adult body size range. This length is far greater than that found in any of the New Zealand lizard taxa known to be extant. Indeed, it is approximately half of the total head plus body size of the largest representatives of both families—160 mm SVL for *Hoplodactylus duvaucelii* (Russell and Bauer 1986) in the Gekkonidae, and 143 mm for *Leiolopisma homalonotum* (Gill 1985) in the Scincidae. Both of these lizards have maximal mandibular lengths of well below 40 mm. The size of

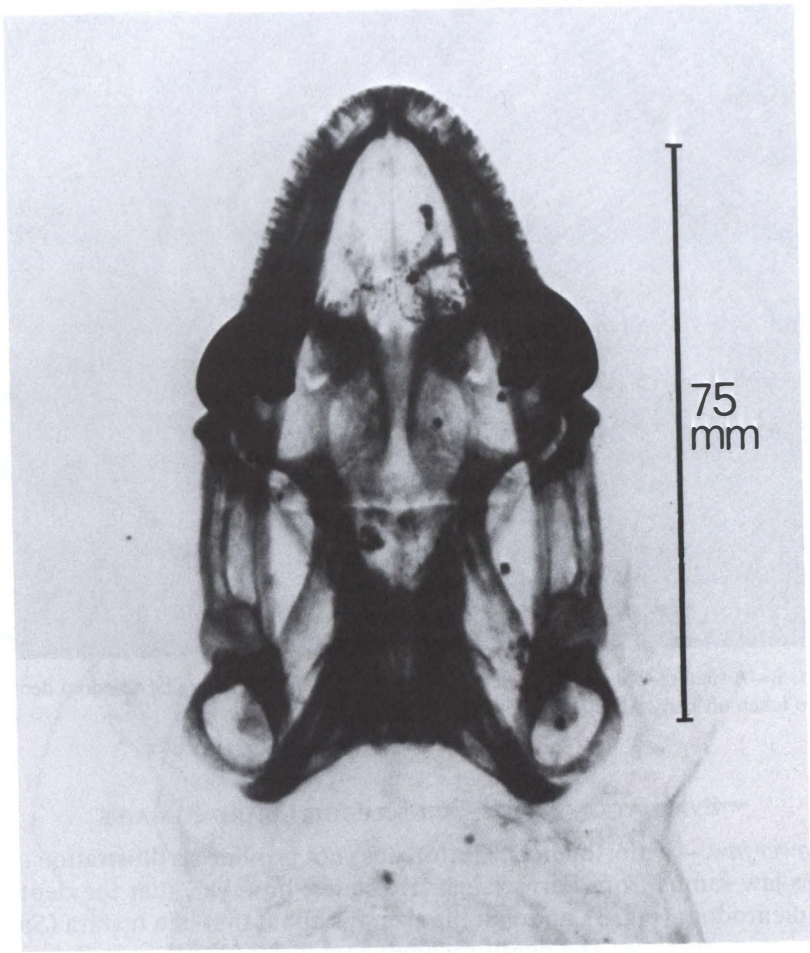

FIG. 6.—Radiograph of the skull of *Hoplodactylus delcourti*. The 75 mm bar represents the approximate size of an adult tuatara, *Sphenodon punctatus*, skull.

the dentary of the largest subfossil New Zealand skink yet reported, estimated SVL at 155 mm (Gill 1985), suggests a total mandibular length of only about 32 mm. By contrast, the jaw ramus of *H. delcourti* is approximately 82 mm in length (extent of the retroacticular process is partially obscured on the radiographs) (Fig. 6).

Rib.—The bone believed by Hutton (1899) to be a posterior cervical rib is problematic. Hutton described the bone (Fig. 4A) as being 14 mm in length (measured along the curve), and possessing a distal row of denticulations on the flattened portion of the element. Its overall aspect was described as

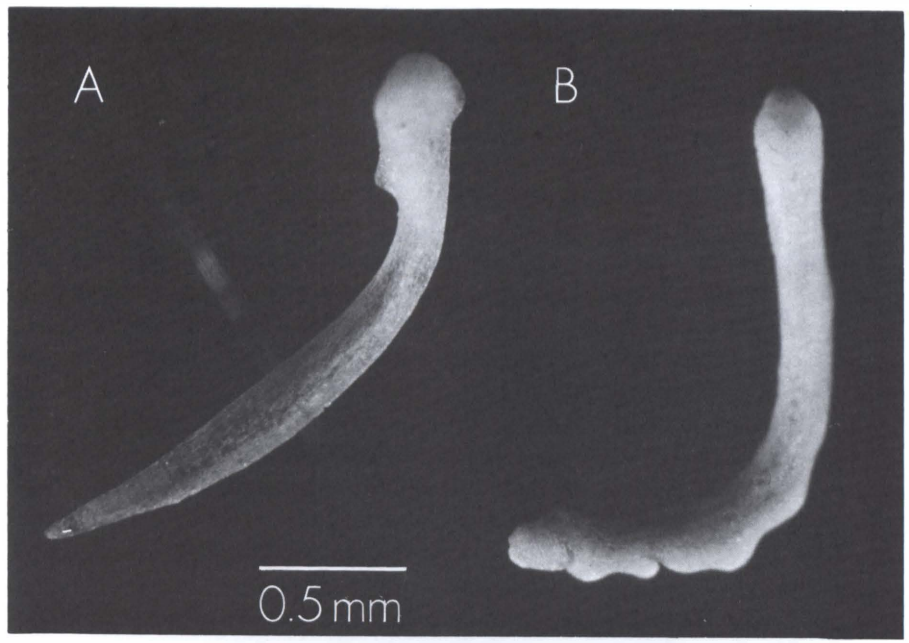

FIG. 7.—A. Anterior cervical rib from the right side of *Hoplodactylus maculatus* (Aaron M. Bauer pers. coll. 88). B. Right medial cloacal bone from the same specimen.

"robust." A comparison with the skeletons of living species of geckos, skinks, and *Sphenodon* has revealed that Hutton's conclusion as to the identity of the bone was incorrect. Hutton (1899) himself stated of the bone: "It is, indeed, unlike anything known to me."

Hutton's identification of it as a rib may have been based on the apparent bicondylar "head" of the element, and its curvature. However, this arrangement, typical of mammals, does not generally occur in lepidosaurian reptiles, which possess single rib heads (Stephenson and Stephenson 1956). The posterior cervical ribs of both geckos and skinks have a broad head and taper into a narrow, somewhat flattened shaft which again expands distally, yielding a barbell shape. The distal portion of the ribs is often partially cartilaginous. Typically, there is little curvature along the length of the ribs. The more posterior ribs—sternal, mesosternal, and thoracic—are thin and elongate, entirely unlike the Earnscleugh element.

Only the anterior cervical ribs (especially the second) bear a resemblance to the bone from Otago (Fig. 7A). Both bear a small proximal flange, and a flattened distal portion. However, the curvature is different, and there are never denticulations, and, again, there is Hutton's statement that the bone was unlike any known to him. Likewise, there is no element in the appen-

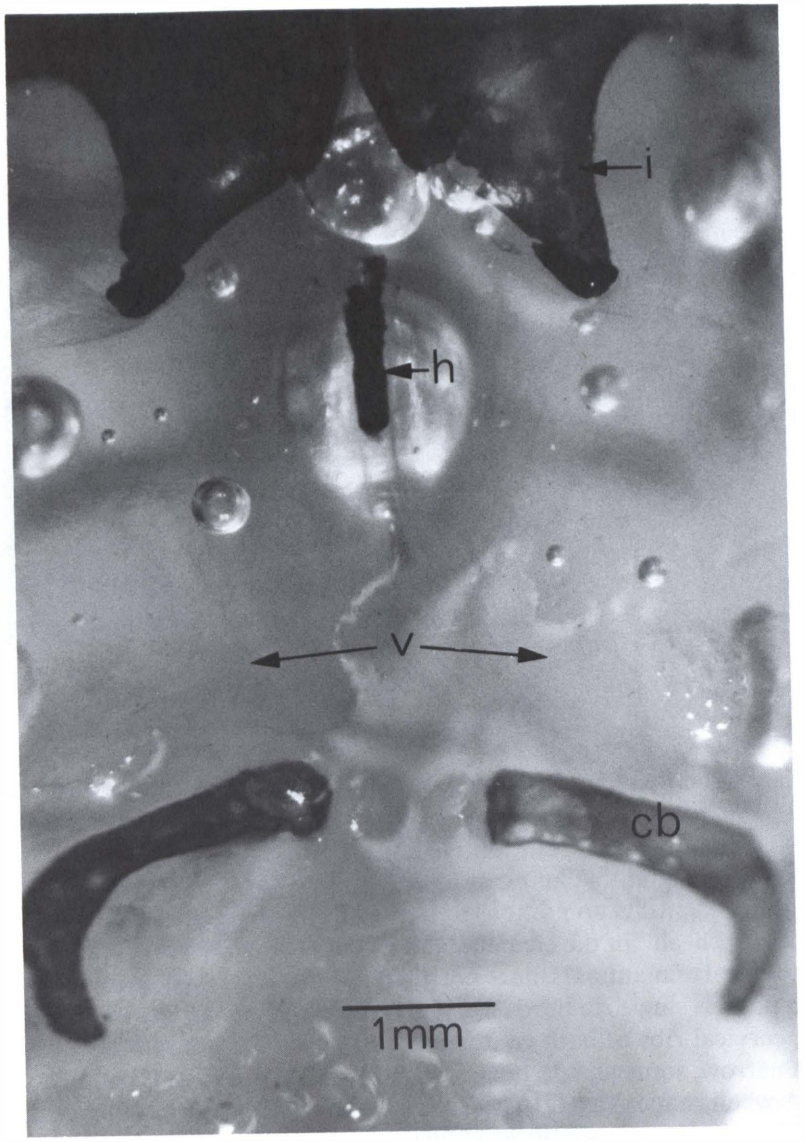

FIG. 8.—Cloacal bones *in situ* in a cleared and stained specimen of the gekkonine gecko *Ptychozoon lionatum* (Anthony P. Russell pers. coll. 54). cb = cloacal bone, h = os hypoischium, i = ischium, v = position of vent.

dicular or axial skeletons of geckos or skinks that approximates the element from the cave deposits.

The closest match to the element is the medial cloacal bone (or "postcloacal" bone). Cloacal bones are small, paired elements typically present in association with the hemipenes of geckos (Fig. 8). These structures were first noted in *Gekko japonicus* by Schlegel (1838), and have since been reported in males of most taxa of geckos, excluding those of the New World sphaerodactyline radiation (Wiedersheim 1876, Kluge 1967, 1982, Russell 1977, Bastinck 1986). They are also present in the highly derived geckos commonly accorded separate familial rank, such as the Pygodopidae (Kluge 1967, 1974, 1987). Similar but apparently non-homologous elements are found in the North American night lizards, Xantusiidae (Savage 1957, Rieppel 1976), and in certain fossil "prolacertilians." There may be two sets of cloacal bones in geckos, a larger medial pair and a smaller pair of often irregular lateral bones. Although many taxa possess only medial bones, lateral elements never occur alone.

The function of cloacal bones is unclear, but they are intimately related to cloacal sacs (Smith 1933), and perhaps to hemipenial stability (Wiedersheim 1876). The bones are usually associated with external cloacal spurs, which may act in the physical enlargement of the aperture of the female's vent prior to intromission (Noble and Bradley 1933, Greenberg 1943, Russell 1977).

Among the taxa examined, the shape and size of the medial cloacal bones varies greatly, even intraspecifically. In all cases, the bone is either C-shaped or J-shaped (see Figs. 4B, 7B, 8). The curvature may be abrupt, as in *Nephrurus,* or more gently bowed, as in *Hoplodactylus* and the majority of the other genera sampled. The "head" or proximal tip of the bone may be enlarged or tapered, or may bear a flange. The shaft of cloacal bones may be rounded in cross-section or compressed. The distal portion may be smooth, but often bears a series of rugosities or denticulations. This is especially true of (but not limited to) taxa that possess lateral cloacal bones as well.

The strongest similarity of the Earnscleugh bone is shown by members of the Tasmantis (New Zealand and New Caledonia) radiation of the tribe Carphodactylini in the subfamily Diplodactylinae. This is the monophyletic group to which all of the living geckos of New Zealand belong (Bauer 1986). The greatest resemblance to the subfossil bone was seen in the species *Hoplodactylus granulatus, Hoplodactylus maculatus* (Fig. 7B), *Naultinus elegans, Naultinus grayii, Naultinus gemmeus* (all from New Zealand), and *Rhacodactylus trachyrhynchus* (from New Caledonia). If this identification is correct, the bone described by Hutton would appear to be a left cloacal bone, with Hutton's illustration (Fig. 4A) representing a dorsal view.

Although there are no diagnostic features to permit the identification of

the Earnscleugh lizard on the basis of its cloacal bone, the size of the lizard can be estimated by comparison of closely related taxa. Table 1 records the SVL and left cloacal bone size (right in the case of *Hoplodactylus delcourti*) in a number of Tasmantis carphodactyline gecko species. Intraspecific measurements vary, especially among juveniles (e.g., *Hoplodactylus duvaucelii*), but clear size trends are seen. The cloacal bones of *H. delcourti* (at 370 mm SVL) are nearly twice as large as those of *Rhacodactylus leachianus* (220–240 mm SVL).

On the basis of the patterns suggested by these measurements, the possessor of a 14 mm cloacal bone would have been approximately 275–325 mm SVL. This is consistent with the size derived from a jaw ramus of 75 mm (a slightly larger size would be implied if the Earnscleugh element were, in fact, an anterior cervical rib). If both bones are indeed from the same animal, they give evidence that a gecko almost as large as the single known specimen of *Hoplodactylus delcourti* was living in Otago until at least the early 1800's.

The Identity of the Earnscleugh Lizard

The large pleurodont jaw reported by Hutton (1875) alone suffices as evidence for the recent occurrence of a lizard larger than any presently known from South Island, New Zealand. If our interpretation of the smaller element from Earnscleugh as a cloacal bone is correct, the animal must have been a gekkonid. The total size of the lizard, as suggested by these elements, would have been slightly less than that of the known specimen of the Maori *kawekaweau,* described by us as *Hoplodactylus delcourti*; but was the Earnscleugh animal conspecific with the *kawekaweau*?

As previously reported (Bauer and Russell 1987), all references to the *kaweau* or *kawekaweau* appear to be derived from North Island, New Zealand, and we have earlier hypothesized that Northland, the region including the Waoku Plateau (Fig. 2), might be the origin of the type of *H. delcourti,* and perhaps the last haunt of the species if still extant. The distance between these areas and Earnscleugh cannot be taken as evidence against the former occurrence of *H. delcourti* in Otago. Indeed, until early European times, both tuataras (Crook 1975, Worthy 1984) and lizard species now restricted to offshore islands (Trevor Worthy, personal communication) were distributed widely across both North and South Island mainlands. The absence of local folklore or reports of the reptile might simply be the outcome of the much less dense Maori settlement of the region and late arrival of European explorers and pioneers.

Hutton (1899) believed that the remains from Earnscleugh Cave might be referrable to the *kumi* or the *ngarara.* Unfortunately, the literature relating to these mythical creatures is vague and confused. Williams (1975) defines the terms respectively as "a huge, fabulous, reptile" and "reptile, monster,"

Table 1.—Cloacal bone size (measured along curve) relative to snout-vent length (SVL) in New Zealand and New Caledonian carphodactyline geckos (as measured from radiographs).

Taxon	SVL (mm)	Cloacal bone (mm)
Hoplodactylus delcourti	370	19.8
H. duvaucelii	74	4.0
	115	7.9
	117	5.2
H. granulatus	72	4.3
H. maculatus	54	2.5
H. rakiurae	58	5.0
H. stephensi	77	5.9
Naultinus elegans	53	4.3
N. gemmeus	67	4.0
N. grayii	90	6.3
Bavayia sauvagii	63	2.7
Eurydactylodes vieillardi	51	2.9
	56	4.0
Rhacodactylus auriculatus	121	6.3
R. chahoua	136	6.5
R. ciliatus	117	7.6
R. leachianus	220	11.5
	240	10.4
R. sarasinorum	125	8.5
R. trachyrhynchus	170	9.7
	175	9.2
Earnscleugh Cave Lizard	275–325 (estimated)	14.0

hardly definitive in a biological sense. The *kumi* was described by Hector (1899) as 5–6 feet in length and he considered it to be related to Australian "iguanas" (= goannas or monitor lizards, family Varanidae). This large size, combined with the improbable attribute of six-leggedness (Hector 1899) makes identification with any known (or even suspected) New Zealand vertebrates highly unlikely.

The *ngarara,* or *unu ngarara* was referred to by Stack (1875) as an animal inhabiting the region of Eyreton (vic. Christchurch), with burrowing habits, a serrated dorsal crest, and large teeth which cause the upper lip to project. Although distinguished from the "ruatara" [= tuatara] by its darker color, the description of the *unu ngarara* is clearly that of *Sphenodon punctatus,* down to the details of the characteristic enlarged premaxillary teeth. A second type of *ngarara* described by Stack (1875) was about 45 cm long, and was said to inhabit streams. This, again, might be a reference to the tuatara, or perhaps to a large scincid lizard such as *Leiolopisma otagense* (although neither this species nor other likely candidates presently inhabit the North Canterbury region).

In combination form, *ngarara-papa* has been suggested as a term for the small brown geckos of New Zealand, *Hoplodactylus maculatus* and *H. pacificus* (Best 1909). Aside from these specific creatures implied by *ngarara,* the term was widely used as a general name for all lizards by many Maori groups (Best 1909, 1923), and in other contexts more closely approximated in its attributes the mythical *taniwha* (Downes 1937, Skinner 1964).

A review of other Maori names associated with lepidosaurian reptiles suggests no obvious alternatives for the Earnscleugh gecko. There may be some association with the *waitoreke,* or New Zealand "otter" (Watson 1960), as these reports derive chiefly from southern South Island, but this is purely speculation. We therefore conclude that either the animal was unknown to local residents or that no record of such knowledge has come to light. On the basis of the lower jaw ramus and cloacal bone, we are confident in our identification of the central Otago giant lizard as a gecko, and tentatively accept that the material represents *Hoplodactylus delcourti,* formerly believed to have been restricted in distribution to North Island, New Zealand.

We do not discount the possibility, however, that the remains may prove to belong to yet another probably extinct giant gecko of the genus *Hoplodactylus* (or less likely, *Naultinus*). Regardless, the Earnscleugh gecko material, with *H. delcourti* and other recent finds of larger lizard remains (Gill 1985), adds to our knowledge of a recent lepidosaurian reptile fauna characterized by incidences of gigantism which persisted until historical times and may still be represented today by *Hoplodactylus delcourti.*

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